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Results of DATAS Investigation of Illegal Mode S ID's at JFK Airport

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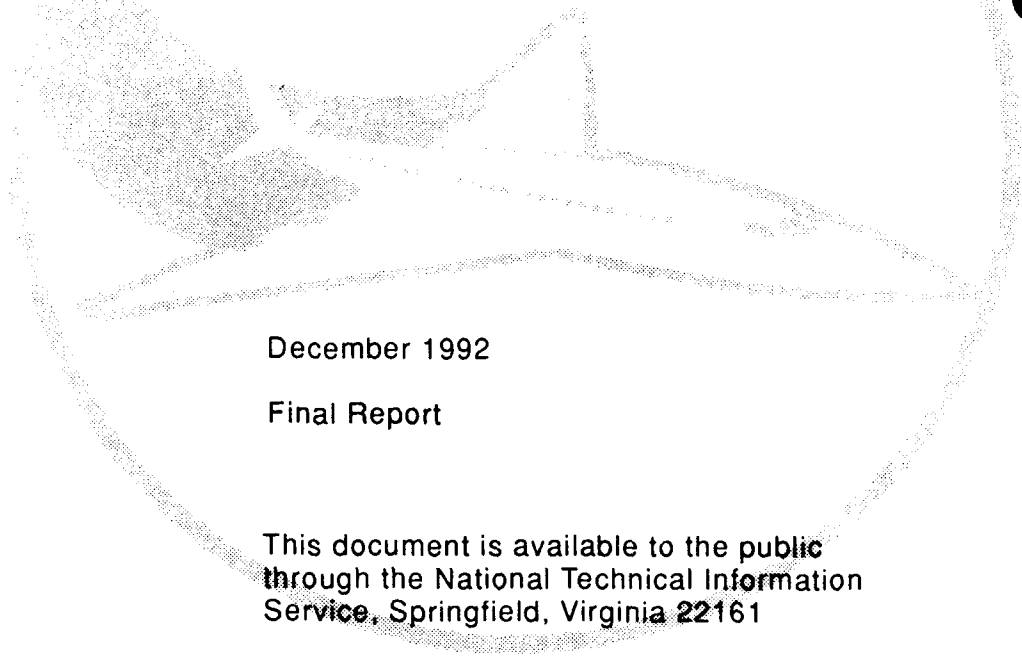

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15. Supplementary Notes

16. Abstract

This report documents the second deployment of the Data Link Test and Analysis System (DATAS) as a Traffic Alert and Collision System (TCAS) monitor. The purpose was to identify aircraft which were reporting Illegal Mode Select (Mode S) ID's. The project was conducted by the Research Directorate for Aviation Technology, Airborne Collision Avoidance & Data Systems Branch, Federal Aviation Administration (FAA) Technical Center.

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The data presented in this report was acquired using the Data Link Test and Analysis System (DATAS). The DATAS was designed and modified to be a Traffic Alert and Collision Avoidance System (TCAS) monitor by the Mode Select (Mode S) ground Data Link development team.

Mr. William Mateer (UAL) was a computer systems analyst for various DATAS applications.

The TCAS monitor application of DATAS required the support of TCAS project personnel including: Mr. Carl Jezierski, TCAS, Program Manager, Mr. Ed Glowacki, Operations Research Analyst, and Mr. Arthur Madge, who was instrumental in coordinating the data collection effort with JFK Airport engineers and Air Traffic personnel.

The deployment of the TCAS monitor at the JFK Airport would not have been possible without the excellent support received from local FAA field personnel including: Mr. Peter Striano and Mr. Marty Happes who were called on many times during the stay of the system at JFK.

Identification of the aircraft with illegal Mode S codes would not have been possible without the cooperation of Mat Calendar of the New York Automation office at JFK. He was called upon to correlate the ATCRBS code issued by the aircraft and the time of coverage in order to get the flight information on the aircraft.

The checkout of the Illegal Mode S ID function was performed at the Philadelphia International Airport. Acknowledgement is made to Mr. Johnie Walker and his personnel for their assistance in this function.

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EXECUTIVE SUMMARY

Since a significant amount of air carriers have recently been equipped with Traffic Alert and Collision Avoidance Systems (TCAS's), there have been reports of Mode Select (Mode S) equipped aircraft which were not tracked by TCAS. Investigation into these occurrences showed that some aircraft were using Mode S identifications which were all 1's or all 0's (both of which are illegal) and some TCAS units do not track those aircraft. If the TCAS system does track the illegal ID's, a possibility of ambiguous actions exists because of more than one aircraft with the same illegal ID. It is mandatory that these aircraft be identified and compelled to use a proper Mode S ID as the system is predicated on each aircraft's possession of a unique ID.

Federal Aviation Administration (FAA) Technical Center Data Link project personnel designed, developed, and deployed a system to record TCAS activity. Through coordinated efforts with TCAS project personnel, the Data Link project design team modified the existing Data Link Test and Analysis System (DATAS) to perform as the TCAS monitor. This system was first deployed at Dallas/Fort Worth (DFW) Airport in Dallas last year to collect data on Resolution Advisories (RA's). This system was later modified to function as an Illegal Mode S ID search vehicle. The system stored aircraft identification data (the Mode S was illegal in this case), capability reports, and altitude histories. The Air Traffic Control Radar Beacon System (ATCRBS) code was also stored as the mechanism of identification. All data transactions were "time tagged" so that it could be correlated with independent surveillance data from systems such as the Automated Radar Terminal System (ARTS) III, ARTS II, or Airport Surveillance Radar (ASR)-9.

The TCAS monitor was deployed at the John F. Kennedy (JFK) Airport. Since the TCAS monitor provides only directional coverage at this time, it was decided to aim the antenna toward the Deer Park very high frequency (VHF) Omni Directional Range (VOR) in order to provide coverage on both arrivals and departures. Coverage up to approximately 30 miles was provided. Data were also collected on other TCAS related activities, such as RA's, as they occurred.

The system was operational from August 25 to September 29, 1992. During that time, approximately 17,500 Mode S flights (from 27 different countries) were acquired and 37 flights with aircraft reporting illegal Mode S ID's (probably 26 different aircraft) were recorded. A problem not previously encountered with RA reporting was also uncovered. Some commuter aircraft report that they have RA information available continuously. When polled for this information, the data fields which describe the advisory contain all 0's. This appears to be a transponder (or transponder/TCAS interface) problem as the reply information (RI) field, which indicates the TCAS capability of the aircraft appears to work correctly (TCAS

vertical resolution capability inhibits automatically at altitudes below 500 feet and the transponder reports this information correctly). The RA reporting function should "clear" after a period of 18 seconds.

INTRODUCTION

Implementation of Traffic Alert and Collision Avoidance System (TCAS) is now in progress as a result of legislation passed by Congress. This legislation also mandates a joint Federal Aviation Administration (FAA)/airline industry operational evaluation of the system. The TCAS Transition Program (TTP) requires data recording systems in order to provide data for analysis during the early stages of TCAS implementation.

The primary objectives of the TTP are to evaluate the operational performance of a large number of TCAS installations and assist in the integration of these units into the National Airspace System (NAS). Government, airline industry, and equipment manufacturers represented on the TTP will investigate and resolve all non-certification related operational problems associated with TCAS implementation.

The operation of the Mode Select (Mode S) (and TCAS which uses the Mode S protocol) system relies on each aircraft to have a unique address in order to selectively interrogate each aircraft. When not properly installed, the aircraft Mode S installations usually have an address of all 0's or all 1's. Neither of these is legal and can lead to ambiguities in the TCAS environment as transponders produced by different manufacturers do not react the same to these illegal addresses. The Data Link Test Analysis System (DATAS), developed at the FAA Technical Center, was modified to provide a TCAS monitor function in addition to its existing functions. DATAS, as a TCAS monitor, operated independently of the TCAS systems to collect TCAS data (such as Resolution Advisories (RA's) as well as illegal addresses) from the ground.

SYSTEM CONFIGURATION

Only a brief description of the system configuration will be provided. The users guide for the TCAS monitor (report DOT/FAA/CT-TN90/62) also includes a more detailed description. The TCAS monitor function is described in the report on testing at DFW airport (report DOT/FAA/CT-TN91/56).

The DATAS (as used in the TCAS monitor application) is basically a programmable transmitter/receiver unit with radio frequency (RF) output capability in the frequency range of 950 to 1150 megahertz (MHz). The transmitter has two completely independent channels whose outputs are combined if the high power transmitter output is selected. Several RF outputs are available for different applications. The frequencies, pulse widths, and amplitudes of all RF outputs are programmable. However, on the high power transmitter output, the power output is fixed. This is a limitation of the modified APX-76 airborne interrogator which is

fixed. This is a limitation of the modified APX-76 airborne interrogator which is normally used by the U. S. Air Force for Air Traffic Control Radar Beacon System (ATCRBS) interrogations. The output power of this unit was reduced to reduce the coverage area to approximately 30 miles.

The receiver of DATAS is a single channel and is programmed to operate at a frequency of 1090 MHz when used as a TCAS monitor. The DATAS contains sophisticated pulse processing capability which is also programmable. Pulse characteristics such as RF frequency, amplitude, spacing, and pulse widths are stored for each reply pulse. The decoders which detect replies to DATAS interrogations are also programmable. In the TCAS monitor, the decoders were set up to detect the arrival of Mode S replies. The time of arrival of these replies is then saved (referenced to a moveable listening "window" which is under program control) in order to provide the radar range of the reply. The Mode S reply code is also stored and sophisticated code correction capability is included in order to overcome interference primarily from ATCRBS replies which may overlap the desired replies.

The TCAS monitor configuration of DATAS contains two processors. The first is a 68020 processor which performs the normal system functions of DATAS in its role as a limited Mode S sensor as well as control of the DATAS hardware. Any one of several ports (i.e., bench port, high power antenna port, diagnostic port, and medium power antenna port) can be selected for use by the RF receiver under program control. The second processor of DATAS is a personal computer (PC/AT) which communicates with the DATAS 68020 via the system Versa Module Extended (VME) bus. This processor is primarily for data analysis. Data collected via the 68020 can be transferred to the PC where it is manipulated and placed in a format compatible with standard commercial data base program packages. Data is retrievable via modem/phone line interface if desired (a cellular phone link was used at JFK).

This system provides coverage of approximately 35^{o} azimuth by 30 mile range. It monitors all Mode S equipped aircraft within this "azimuth wedge" while awaiting the arrival of an aircraft with an illegal Mode S ID or an active "TCAS RA." When either event occurs, data on all Mode S aircraft present within this azimuth are stored on disc for future analysis. All interrogations were Mode S type interrogations except for one special case. If a Mode S transponder reports an address of all 1's, it may or may not respond when interrogated with this address (dependent on manufacturer). The all 1's address is reserved for "broadcast" interrogations by Mode S protocol. When TCAS or Mode S sensors issue a message with an address of all 1's, it is received by all transponders as a "broadcast" and no reply is required. If the transponder follows this protocol, it will not reply when

interrogated with an all 1's address. If the transponder does not respond, the DATAS will switch to the ATCRBS mode and interrogate until it receives the ATCRBS identification code of the illegal aircraft. This is accomplished by a range correlation of the "Mode S All Call" (which provides the Mode S ID) and the ATCRBS replies received when in the ATCRBS Mode.

The azimuth wedge for coverage by the DATAS was selected after coordination with JFK air traffic personnel. The basis for selection was the ability to collect data on both arrival and departures.

The DATAS equipment was installed in a van so that space for installation at existing sites was not required. The DATAS van was parked adjacent to the Instrument Landing System (ILS) localizer at the perimeter of the JFK Airport. After the initial installation, the equipment was operated as a completely unmanned facility for a period of approximately 1 month. Data were extracted via modem/cellular phone and analyzed at the FAA Technical Center.

OVERALL DATA DISCUSSION

The DATAS was installed at JFK for a period of approximately 1 month. During this time, data were stored for all aircraft under coverage when one of three events occurred:

1. The aircraft reported an illegal Mode S ID.
2. The aircraft reported an RA.
3. The TCAS reported capability changed (i.e., active to inactive, etc.).

A modification was made to the program for approximately the last 1/3 of the data collection period, allowing better overall statistics to be gathered which were independent of the storage options.

Total data collection time	514.8 hours
Total No. of Mode S aircraft	17,472
Percentage of Mode S aircraft with TCAS active (this was based on a smaller sample than the total)	56%

The above data show that the total operating time for the DATAS was approximately 515 hours. The operation was 24 hours per day except for certain system malfunctions. Several outages went unnoticed over the weekends because data retrieval was the only method of knowing that the system was up, and this was not performed except during the standard work week. When a malfunction did occur, it was necessary to wait for local personnel to go out to the van (at their

restoring the system to operation. One trip was required by FAA Technical Center personnel for "on site" troubleshooting. The latest data collection modifications were also installed at this time as well as a second modem port for data retrieval.

During the system operation at JFK, a total of 37 flights with illegal Mode S ID's were covered. The flight information was acquired for all but 5 of these flights. In the early portion of the data collection period, we were unable to get the flight information if the flights did not land at JFK. During the later phase of data collection, we were able to get this information from the New York and Boston Air Route Traffic Control Centers (ARTCC's) by providing them with the ATCRBS codes and time of day. Table 1 shows a summary of the illegal Mode S ID data. All of the illegal ID's were foreign except two. One of the two American planes reported a hexadecimal address of "FFFFFF" (all 1's). The other, however, reported "8AAE94" which is also illegal. It was traced to a Delta Airline flight by the Boston Center. It appears to be a missing bit in the address (probably should be AAAE94). When a program which relates Mode S address to aircraft tail number was run it was learned that "AAAE94" is part of the block assigned to Delta Airlines (788DL). "AAAE94" was not present in our data at any time during the period. This one bit error is not a problem for the system, but it makes a duplicate address possible if "8AAE94" were a legal address.

TABLE 1. ILLEGAL MODE S ID'S AT JFK

DATE	TIME	MS ADD	CODE	FLIGHT #	AIRLINE
8/25	14:39	000000	2632	AFR006	AIR FRANCE
8/25	21:45	FFFFFF	3627	??????	(OVERFLIGHT)
8/26	22:20	000000	3161	JES203	AIR BULGARIA
	23:00	000000	7056	TAI710	TACA
8/27	02:15	000000	1647	JES204	AIR BULGARIA
8/28	13:40	FFFFFF	1002	AEA076	AIR EUROPA (SPAIN)
	15:05	000000	2415	AFR006	AIR FRANCE
	16:45	FFFFFF	4030	AEA077	AIR EUROPA (SPAIN)
	20:22	000000	1644	AFR007	AIR FRANCE
8/31	20:42	000000	3452	AFR008	AIR FRANCE
	22:22	000000	0575	TAI710	TACA
	22:50	000000	2666	AFR009	AIR FRANCE
9/01	21:04	20044B	2312	BAW179	BRITISH AIRWAYS
	23:02	000000	6503	TAI710	TACA
9/02	19:10	000000	2341	??????	(ON THE GROUND)
9/03	07:07	000000	3013	TAI711	TACA
	08:45	000000	0661	N2601	(OVERFLIGHT-PRIVATE)
9/10	10:30	000000	1704	N375SC	(PRIVATE)
9/11	13:45	000000	6575	N375SC	(PRIVATE)
9/12	22:37	000000	0516	TAI710	TACA

TABLE 1. ILLEGAL MODE S ID'S AT JFK (Continued)

DATE	TIME	MS ADD	CODE	FLIGHT #	AIRLINE
9/13	07:21	000000	3327	TAI711	TACA
	19:27	000000	0716	JES203	AIR BULGARIA
9/14	00:20	000000	1760	JES204	AIR BULGARIA
	09:51	FFFFFF	1376	??????	(OVERFLIGHT)
	18:07	000000	3023	??????	(OVERFLIGHT)
9/17	01:32	000000	6664	JES201	AIR BULGARIA
	04:20	000000	2004	JES201	AIR BULGARIA
9/18	14:50	FFFFFF	2701	??????	(OVERFLIGHT)
	17:42	FFFFFF	3005	AEA077	AIR EUROPA (SPAIN)
9/20	22:10	000000	3071	JES204	AIR BULGARIA
	09:36	FFFFFF	1315	UAL179	UNITED AIR LINES
9/23	07:12	000000	2626	TAI711	TACA
	19:50	000000	3113	JES203	AIR BULGARIA
	22:06	000000	2751	JES204	AIR BULGARIA
9/28	19:30	8AAE94	3572	DL252	DELTA AL-BOSTON CTR

Figure 1 shows the 37 illegal ID's as a function of the time of occurrence. This figure shows that the illegal ID's occurred primarily late at night. Seven flights with illegal ID's occurred between 22:00 and 23:00 hours. This is probably because almost all of the flights were international flights which departed for JFK during the day. Some of these flights were duplicates, but the data collected at JFK cannot determine whether the same or different aircraft was used because the Mode S ID was illegal. In order to learn this information, we must contact the airlines and find out which aircraft was used for the particular flight on a certain day. By using the arrival/departure data it is estimated that there were 26 different aircraft.

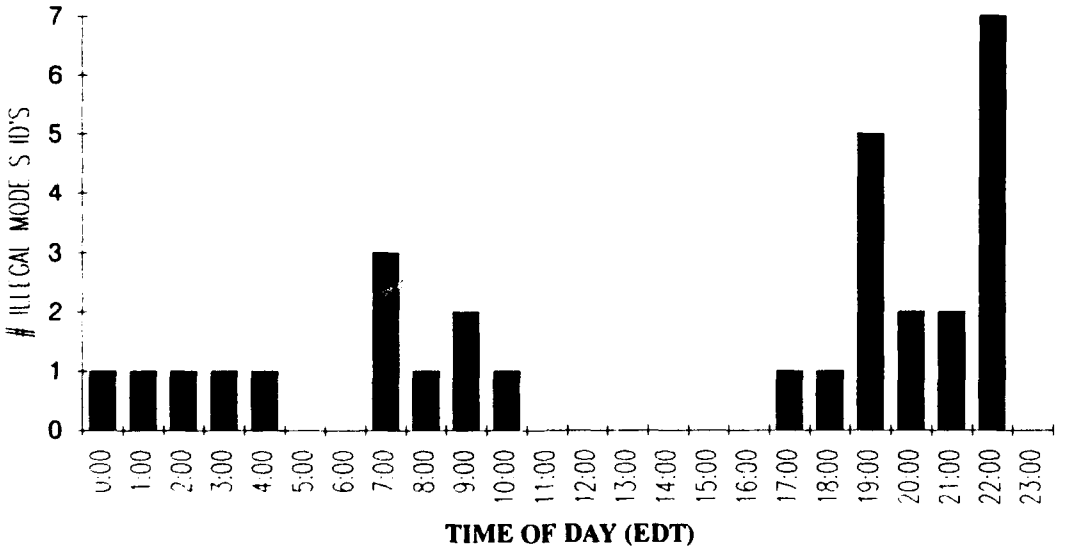

FIGURE 1. ILLEGAL MODE S ID'S VS. TIME OF DAY

Figure 2 shows that the illegal Mode S ID's are primarily all 0's. The "others" category consists of two aircraft. One of those is the American plane discussed above which appears to be a dropped bit in the address. The other is a British Airways plane whose address was "20044B." The normal address block for England is "40xxxx," so the illegal address is not merely a missing bit as in the other case.

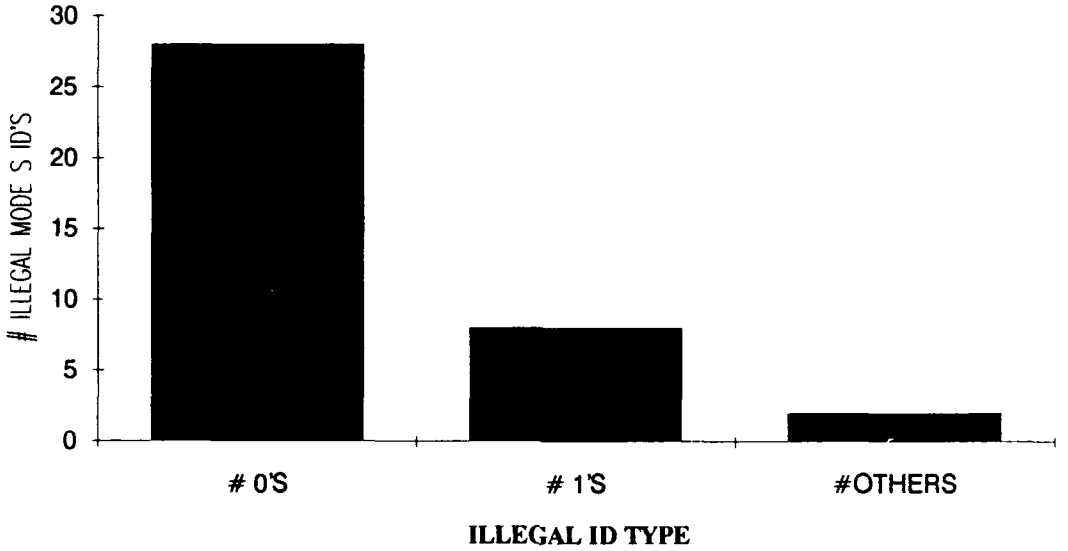

FIGURE 2. ILLEGAL MODE S ID'S TYPE

Figure 3 shows that the illegal ID's are almost all from foreign flights. A total of 264 different Mode S ID's from 27 different countries were tracked during the test period. It must be pointed out that the data shown in figure 3 may not contain all the foreign Mode S equipped aircraft as the storage option selected resulted in stored data only if a TCAS capability was changed during the time of coverage. The TCAS capability normally changes from "vertical only" to "traffic advisory only" (and vice-versa) at an altitude of approximately 500 feet. An additional option is now being added which will allow information storage on all foreign aircraft independent of the storage option selected.

England is the foreign country with the most different Mode S equipped aircraft (28) from this data sample. Only two flights from an English-based airline reported illegal Mode S ID's. Both of these were for a very short interval, so there may be another problem there. The normal flight was under coverage for 5 to 10 minutes, and both the illegally addressed English aircraft reported for only a few seconds.

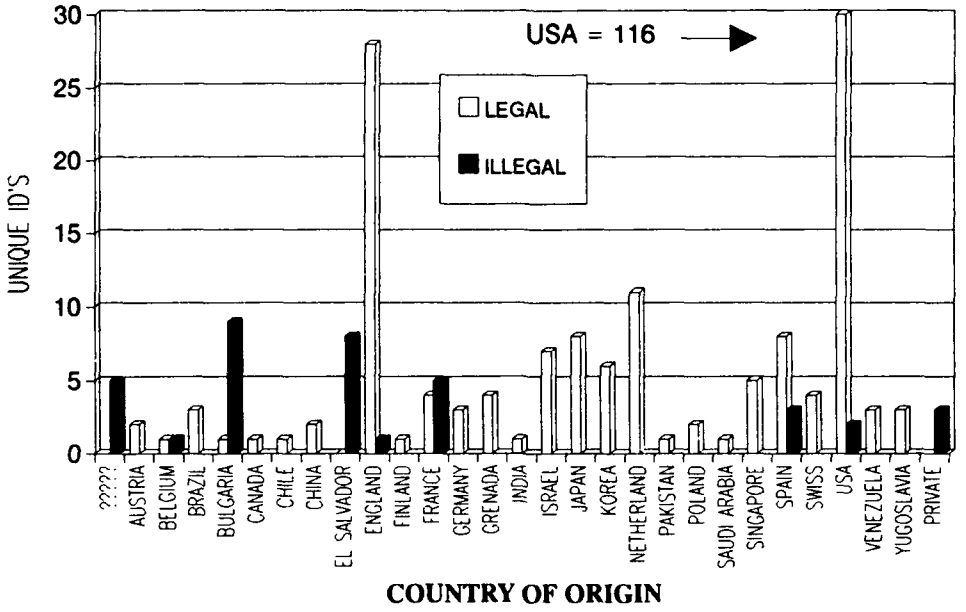

FIGURE 3. ILLEGAL MODE S ID'S AS A FUNCTION OF COUNTRY

There were five flights which were not identified (shown as ?????). These flights were overflights (we did not learn how to identify these via the ARTCC (Boston or New York) until the later phases of data collection). One of the unidentified aircraft was on the ground and, therefore, not in the Automated Radar Terminal System (ARTS) III. Three flights were private aircraft (two different aircraft). The flight information on the private aircraft is known, but not the tail numbers.

These data probably show the transition of the installation of the Mode S transponders in the aircraft. Mode S transponders receive the Mode S ID via cable harness.

Figure 4 shows the illegal ID's as a function of flight number. The most illegal ID's on the same flight number occurred on Flight TAI710. This is an airline based in El Salvador. The companion flight for this aircraft is probably TAI711. Bulgaria (JESXXX flights) provided the most flights with illegal Mode S ID (9). Most of the illegal ID's appeared to occur in pairs (i.e., AFR006, AFR007), probably a landing and takeoff of the same aircraft which occurred a few hours apart.

The most serious problem is the possibility of more than one illegal Mode S ID present in the same airspace at the same time. Two "all 0" Mode S ID's were measured within 20 minutes of each other during the period. If other TCAS units do not track them, the possibility of directing another aircraft into them exists. If they do track them, the possibility of coordinating with the wrong aircraft exists as

both have the same Mode S ID. Before the data collection effort, it was assumed that since there were very few illegal Mode S ID's, the probability of having two different ones present in the same airspace at the same time was remote. The data from JFK shows that this assumption is not valid. These flights are scheduled to be in the same airspace at nearly the same time, so the problem must be addressed immediately.

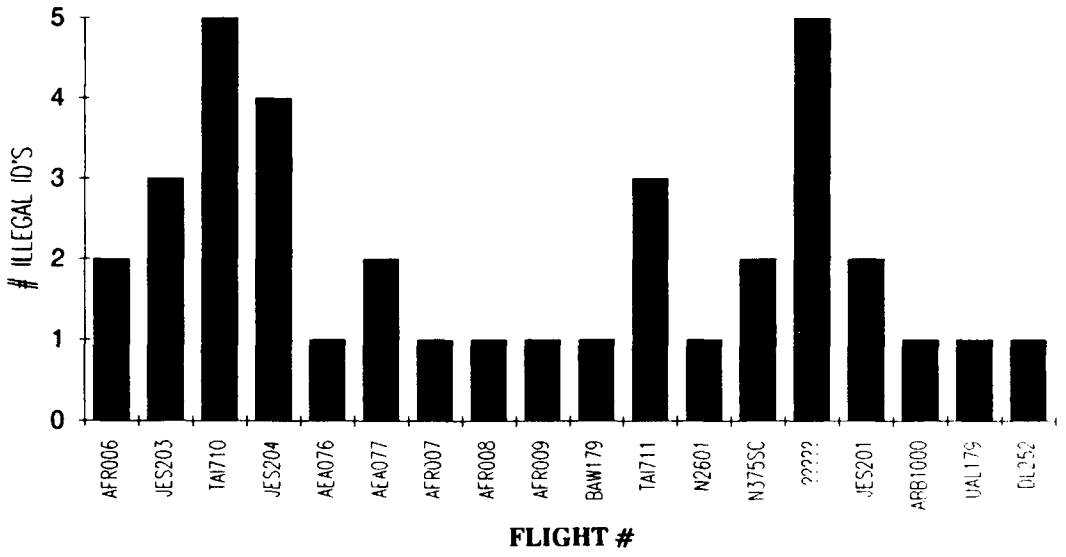

FIGURE 4. ILLEGAL MODE S ID'S AS A FUNCTION OF FLIGHT NUMBER

RA DATA DISCUSSION

The data storage option selected during the data collection phase at JFK included the standard "RA data" option. It was noticed that there were an inordinate number of RA's occurring for no apparent reason. Investigation showed that almost all of the RA's which were reported were not real (all zeroes in the data which describes the RA type).

The RA data were extracted via modem/cellular phone for the first 2 weeks of operation. Analysis of these data showed that the RA's were reported by the same aircraft during different arrival or departure legs of the flight. Figure 5 shows the number of RA's and total duration of "RA reported" time for the 54 different aircraft which reported "all 0" RA's during the period. All are commuter aircraft. Aircraft No. 10 reported the most RA's (12) for a total time of 1 hour and 20 minutes. Aircraft No. 51 reported active RA's for a total of 1 hour and 55 minutes of coverage.

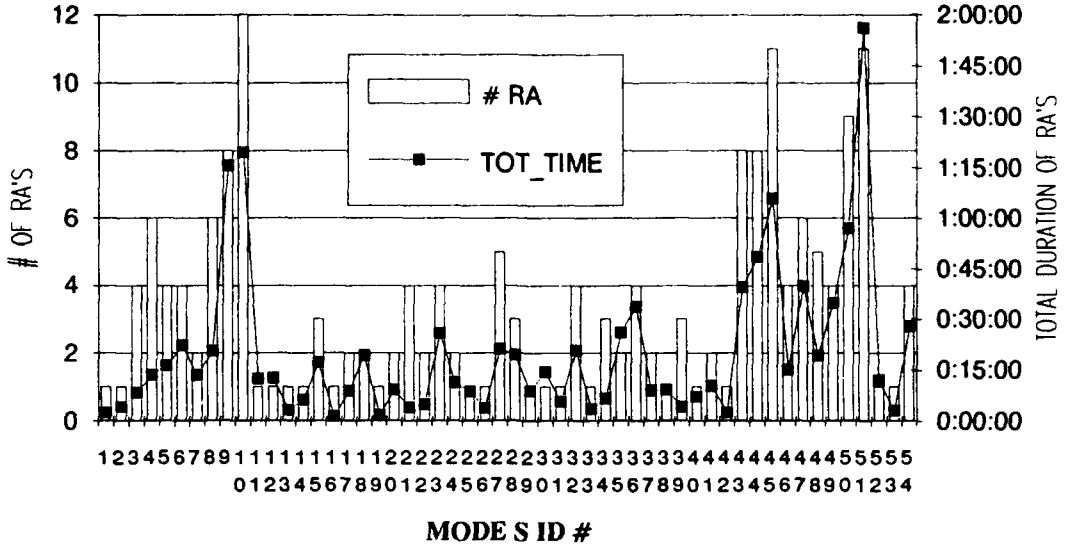

FIGURE 5. MULTIPLE ALL ZERO RA'S

The actual time of reporting RA's is probably much more than the amount shown because the aircraft flew in and out of coverage when arriving and landing at JFK. This is easily shown by the one aircraft scenario described below. The dates from August 20-24 were at the Philadelphia International Airport (which was used to check out the newly added functions because of its proximity to the FAA Technical Center).

1. The aircraft was first acquired on August 20 at 17:50:03 at a range of 1.1 miles and an altitude of 300 feet. It reported an RA equal to all zeroes and the correct TCAS capability of "advisory only" (this is an automatic TCAS function below 500 feet). It was tracked to 2.3 miles and 800 feet at 17:50:35. The TCAS capability switched to "vertical only" when the altitude of the aircraft was greater than 500 feet, indicating that the TCAS was active and this information was reported correctly. The target then dropped until 17:53:20 when it was again acquired at 7.5 miles and 4,000 feet (the RA was still active). It was tracked to 19.6 miles at 4,900 feet with an ATCRBS code of 4237. It was then dropped until 18:00:53 when it was again acquired at 28.3 miles, still at 4,900 feet. It was tracked to 39.8 miles when it had descended to 3,900 feet (ATCRBS still = 4237).

2. The aircraft was again acquired on August 20 at 23:44:02 at 13.2 miles and 3,800 feet with an ATCRBS code of 4234 and an active RA = 0. It landed at 23:48 and the RA of all zeroes was still active.

3. The aircraft was then acquired again at 00:12:18 (August 21) while taking off. It reported an ATCRBS code of 5322 until 13:39. At this time, the ATCRBS code

changed to 1200. The aircraft was last reported at 15.8 miles and 700 feet at 00:18:57. The RA of all 0's was still active.

4. The aircraft was again acquired at 08:55:27 (August 21) at 300 feet and 0.4 miles with an ATCRBS code of 4306. It did not have an active RA at this time. It was tracked until 09:00:10 at 12.3 miles and 4,600 feet (still no RA). The TCAS status information was again correctly reported as the aircraft crossed the altitude threshold of 500 feet.

5. This same aircraft was seen while at JFK multiple times. The table below lists the times of coverage. It reported an all 0 RA every time it was seen at JFK (12 times).

TABLE 2. JFK COVERAGE OF AIRCRAFT NO. 10

Date	Start Time	End Time	RNG_1 (mi)	RNG_n (mi)	ALT_1 (feet)	ALT_n (feet)	Code
8/29	14:20	14:27	13.1	0.5	4000	300	1477
9/2	14:36	14:42	16.8	0.5	2700	0	3517
9/2	16:31	16:38	4.7	15.6	2500	7900	3353
9/2	19:12	19:17	12.5	0.5	2000	0	2005
9/12	09:09	09:17	1.2	4.6	3700	900	1303
9/12	10:18	10:21	0.8	5.9	900	4500	3070
9/12	18:23	18:30	18.7	0.7	3700	0	2016
9/19	14:42	14:47	20.8	15.5	4100	4000	2024
9/19	16:56	17:01	0.6	1.1	1400	6600	2730
9/19	19:30	19:37	25.0	14.2	4000	3000	3577
9/19	21:08	21:17	0.6	22.6	4800	7900	3076
9/23	20:26	20:29	4.2	0.6	1100	0	5625

It is evident that this aircraft is not always landing at JFK. Note that on September 12 at 09:09 the aircraft was picked up by DATAS at 1.2 miles and an altitude of 3,700 feet. It tracked the aircraft until 09:17 when it was at a range of 4.6 miles and had descended to 900 feet. It was probably landing at a nearby airport.

Collectively, these aircraft reported 184 RA's for a total time of more than 18 hours. The Mode S sensors which would have handled these RA reports would have retrieved them for much more time than that because they have the aircraft in coverage for 360^{o} rather than the 35^{o} coverage of DATAS. It is obvious that the RA reporting was only reset when the transponder power was turned off. It then

functioned properly until an RA occurred, and then continued to report falsely the active RA from then on.

There are actually two problems with the transponders described above: (1) the RA does not terminate properly (within 18 seconds), and (2) the reported RA is always all zeroes. Data indicates that the problem is in the transponder or in the interface between the TCAS unit and the transponder. The TCAS capability appeared to be reported correctly in all cases. The "Downlink Request" (DR) field of the transponder, which indicates the presence of TCAS information, is probably being handled incorrectly. Other downlink requests, such as "Comm B broadcast available" were also noticed in the surveillance data. These did not trigger any action by DATAS (TCAS information available results in a different mode to acquire the TCAS information) but are probably part of the same problem.

This problem is probably not significant at this time, because the intended user of this reporting function is the Mode S sensor and they are not yet deployed. After their deployment, however, the constant attention required to properly handle these RA's will require the usage of valuable "RF link" time, which is already in short supply.

CONCLUSIONS

1. The percentage of illegal Mode S ID's at JFK Airport is extremely small. There were a total of 37 illegal ID's out of more than 18,000 Mode S flights. These were probably from 26 different aircraft.

2. Most of the illegal Mode S ID's at JFK Airport were reported by foreign airlines (30 of the 32 which were identified). Aircraft from 27 countries were tracked and all aircraft from 20 of them were illegally addressed.

3. Most of the illegal Mode S ID's at JFK Airport were detected at night.

4. Most of the illegal Mode S ID's at JFK Airport were all 0's (28 of 37).

5. The presence of more than one "all 0's" Mode S ID in the JFK airspace is very probable. One instance of two "all 0's" arrivals within 20 minutes was recorded. Flights by the same airlines are apparently scheduled for arrival at approximately the same time.

6. There were two cases of illegal Mode S ID's which were not either "all 0's" or "all 1's." One of these was apparently a dropped bit from the address. The other

may have been a shifted bit, but this seems harder to explain as only one bit was shifted.

7. A number of commuter aircraft are falsely reporting RA data as all 0's.

8. These "all 0" RA's do not terminate properly. Some appear to last for hours at a time. A total of 18 hours of RA data were reported by 54 different commuter aircraft while at JFK. One aircraft was also seen at Philadelphia (with an all 0 RA) during the checkout of the DATAS system.

RECOMMENDATIONS

1. Since the bulk of detected illegal Mode S are international carriers, future data collections should be done at airports with heavy international operations.

2. Immediate action should be taken to contact the airlines with all 0 Mode S addresses. This will correct the potentially dangerous situation of multiple illegal addressed aircraft within simultaneous TCAS coverage.

3. The airlines with aircraft which incorrectly report TCAS information availability should be contacted. Corrective action should be taken prior to deployment of ground Mode S sensors.

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